REMARKS / ARGUMENTS

This Amendment is submitted in response to the Office Action mailed on November 27, 2006. Claims 2 - 9, 11 - 17, 27 - 29, and 35 - 39 are pending, and all stand rejected at present, except claims 38 and 39 which are allowed. Claim 40 is added. No fee is due.

This Amendment makes several assertions regarding technical aspects of the references. Applicants offer to submit an affidavit in support of these assertions, if the Examiner requests. However, an affidavit is seen as unnecessary, because the assertions are believed to be based on simple, well-known principles of engineering.

RESPONSE TO ANTICIPATION REJECTIONS

In Paragraph 2 of the Office Action, the Examiner rejected claims 2 – 9 under 35 USC 102(b) as being anticipated by Artus et al. For the reasons discussed below, Applicants believe these claims are not anticipated by Artus.

Artus Reference

Artus wishes to reduce the overall weight of a stepper motor, including the mass of the non-rotating stator, for robotics applications.

He states that reducing the leakage of magnetic flux allows a reduction in weight because leakage flux requires mass to dissipate heat produced by the current which generates the leakage flux. If the leakage flux is eliminated, then the extra mass can be eliminated. (Column 1, lines 13 - 34.)

It appears that Artus reduces the mass by:

1) placing coils 34 in his Figure 1 around some stator teeth 28, but not around other teeth 32,

2) reducing the amount of iron in the latter teeth, by the use of air spaces generated by pins 18, and

3) hollowing out the rotor by means of opening 44.

Applicants wish to point out what they believe are some important features of Artus.

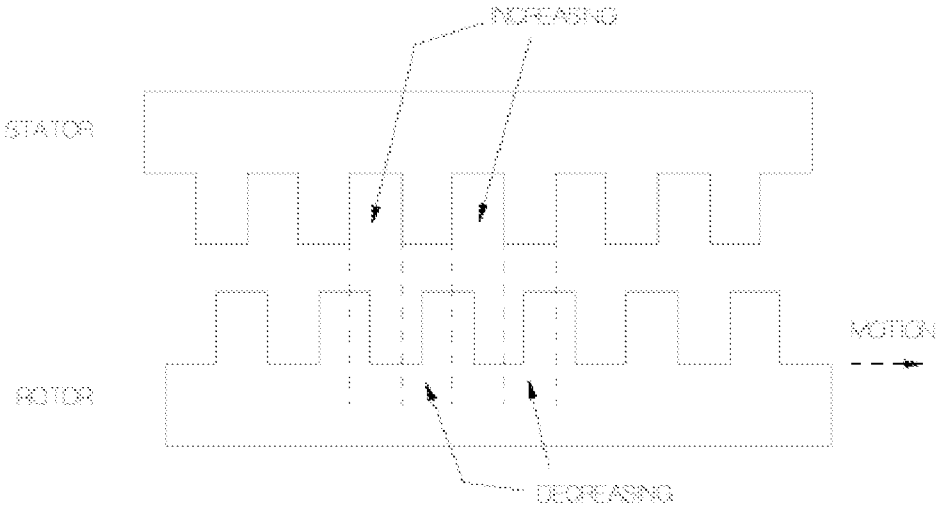
Feature 1

There is no cogging torque in Artus. Artus shows a variable reluctance stepper motor. When the current is shut off, there is no magnet present to cause the cogging described at the beginning of Applicants' Specification.

Feature 2

There is no cogging in Artus' motor for another reason. There is no corresponding change in inductance (or reluctance) in Artus' motor, as described in connection with Applicants' Figure 5. Thus, there is no cogging.

Applicants respectfully submit the following Sketch 1:



SKETCH 1

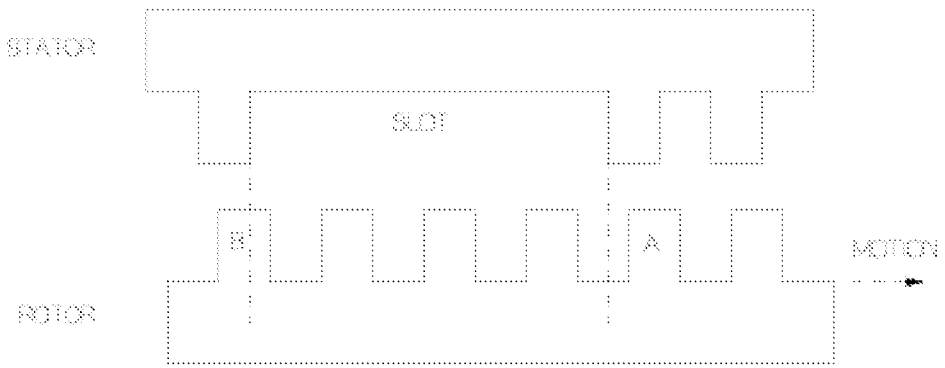
This sketch is believed to represent the teeth on the stator and rotor of Artus, but in linear fashion. When the rotor rotates, as indicated at the bottom of the Sketch, the overall reluctance of his motor does not change. That is, some teeth on the rotor move away from teeth on the stator. That (1) increases reluctance, (2) reduces flux extending between those rotor-stator teeth-pairs, and (3) reduces inductance.

But, at the same time, an equal number of teeth on the rotor move toward teeth on the stator. That has an opposite, compensating effect that (1) decreases reluctance, (2) increases flux extending between those rotor-stator teeth-pairs, and (3) increases inductance.

Stated more simply, in Sketch 1, bottom, the amount of iron within the spaces labeled "INCREASING" is rising. The amount of iron within the spaces labeled "DECREASING" is falling. But the increase cancels the decrease. There is believed to be no net change in reluctance/inductance.

The problem described in Applicants' Specification in connection with Figures 11 and 12, does not arise. The problem is that a change in reluctance/inductance causes cogging torque. But, as just explained, in Artus, these changes are not present.

This conclusion also applies to the spaces between the teeth of Artus, such as the space between his pole members 28 and 30. That space can be represented by the SLOT shown in the following Sketch 2:



SKETCH 2

When the rotor rotates, the tooth labeled A, at the bottom of Sketch 2, leaves the SLOT. But tooth B now enters the SLOT. There is no net change in iron adjacent the SLOT. There is no net change in reluctance/inductance. There is no cogging torque.

The problem described in Applicants' Specification in connection with Figures 11 and 12 does not arise.

Interim Conclusion 1

Artus does not face the problem of cogging torque. Thus, there is no reduction in cogging torque because of his tab 52 in his Figure 4. Applicants' claims 2, 5, 15 and all claims that depend either directly or indirectly from them recite a reduction in cogging torque.

Feature 3

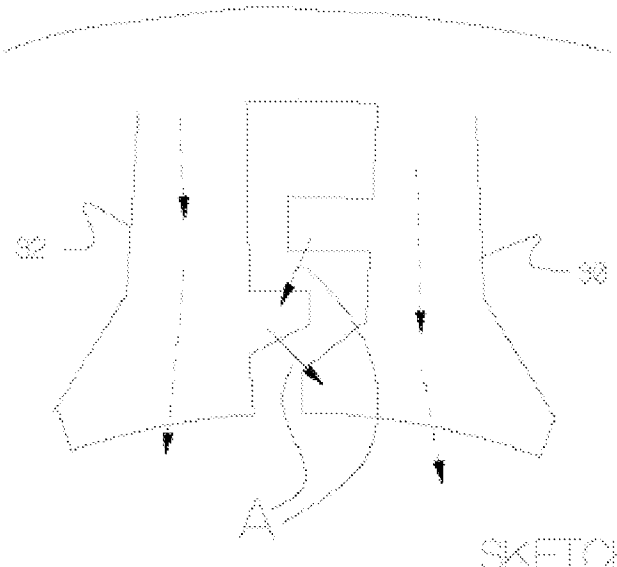
Artus states that he wishes to reduce leakage flux. (Column 1, line 13 et seq.; column 2, lines 1 - 4; column 5, line 24 et seq.)

That militates against the flux of the type shown on "Path A" in Applicants' Figure 14, which is a type of leakage flux.

Feature 4

Artus states that there is no flux leakage "from one stator segment to another." (Column 5, line 27.)

If that be so, then no flux can emanate from tab 56 in his Figure 4. The reason is that if any flux does emanate from that tab 56, some of it will enter tab 52 (on "another" stator as shown on Sketch 6 below), contrary to his statement.



SKETCH 6

Similarly, if any flux does emanate from tab 52, some will enter the radially inner part of element 60 (on "another" stator), near the label "FIG.4." That is again contrary to his statement.

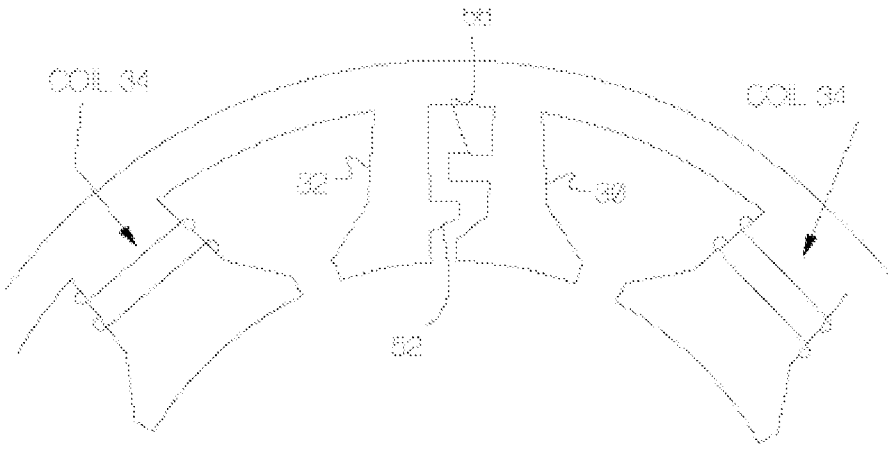
Interim Conclusion 2

Artus states that he eliminates leakage flux. If he does that, then no flux exits his tab 52 in his Figure 4.

The flux of the invention, which facilitates reducing cogging torque, is a type of leakage flux. Artus states that such flux does not (or at least should not) exist in his system.

Feature 5

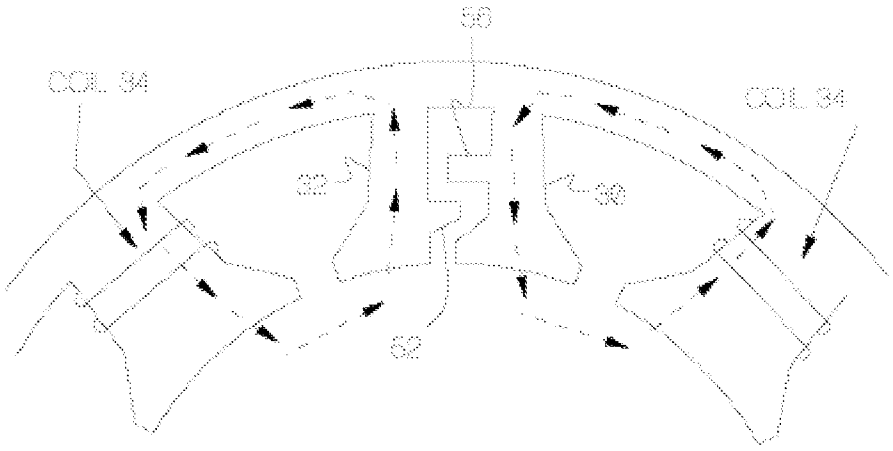
In summary, Artus' device does not teach of what Applicants' claims recite. Current can be applied to a stepper motor in several different approaches. In some of these approaches, the currents create magnetic fields which cancel each other at the locations in question. In the cancellation-situation, no flux is present corresponding to that of the invention. Note the following Sketch 3:



SKETCH 3

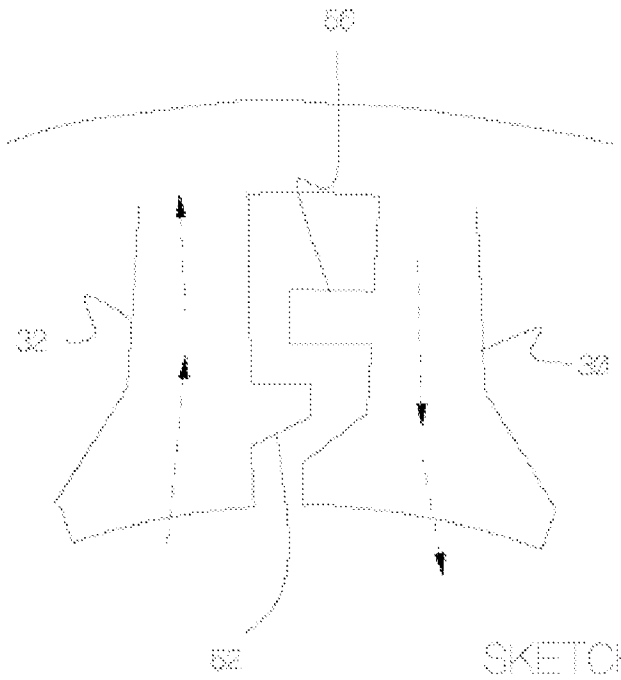
This sketch is a rendition of Artus' device. Coils 34 are present around the teeth shown, but not around pole pieces 30 and 32.

Artus' Figure 3 shows magnetic field 46, but he does not show the magnetic field within both pole pieces 30 and 32. The following Sketch 4, does so:



SKETCH 4

Applicants point out that the magnetic field in piece 30 is opposite to the magnetic field in piece 32. This is shown in detail in the following Sketch 5:



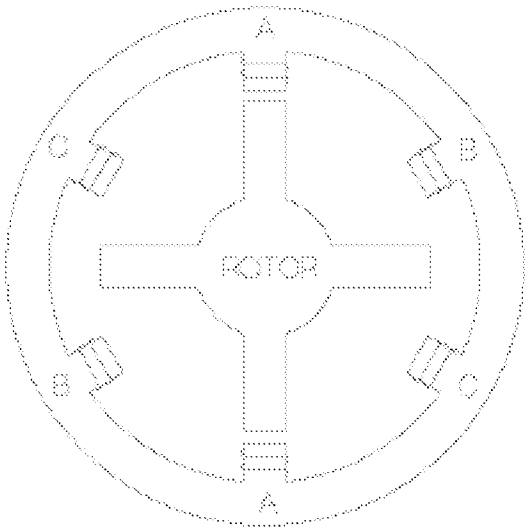
SKETCH 6

Therefore, those fields tend to cancel each other in the region of tab 52. Little, or no, field exits downward from tab 52. Thus, the field added by Applicants' invention in this region is not present. Consequently, the reduction in a change in reluctance (or inductance) in this region, as described in Applicants' Specification, in connection with Figure 13, is not present.

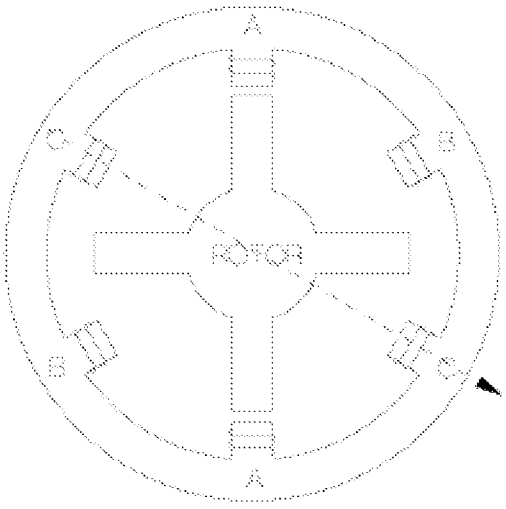
This situation can occur in several modes of operation in Artus.

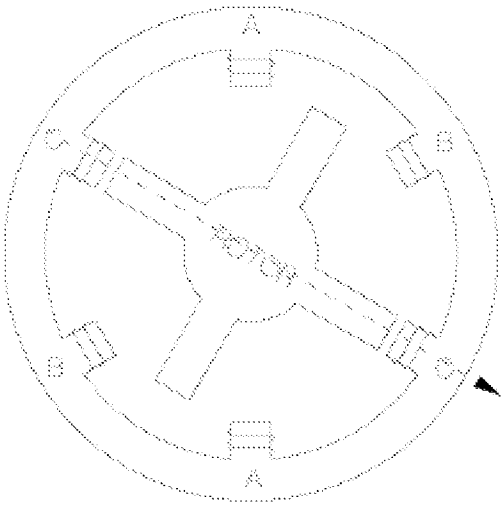
Artus discusses a stepper motor. (Column 1, line 10.) As background, the operation of a generic stepper motor will first be explained.

The following Sketches 7, 8 and 9 below, are considered self-explanatory:

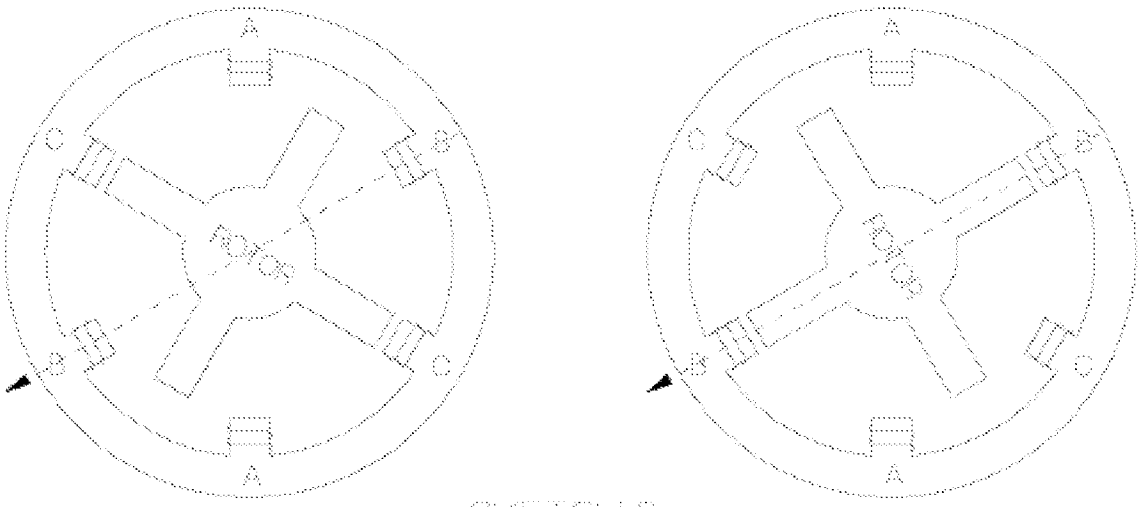


SKETCH 7





SKETCH 8



SKETCH 9

When a current is applied to coils C-C, the magnetic field shown at the left side of Sketch 8 is generated. The ROTOR rotates thirty degrees clockwise, to align with the field, and assumes the position shown at the right side of Sketch 8. That is one "step."

Then, while the rotor is in the position shown, a current is applied to coils B-B, as in the left side of Sketch 9. The ROTOR again rotates thirty degrees clockwise to align with the field and assumes the position shown at the right side of Sketch 9. That is a second "step."

Then current (not shown) is applied to coils A-A, and the process just described is repeated. Details of stepper motor operation can be found in the tutorial by Douglas W. Jones titled "Control of Stepping Motors" at www.cs.uiowa.edu/~jones/step. The operation just described is sometimes called "full stepping."

In "half-stepping," when the rotor is, for example, in the position shown in the right side of Sketch 8, current is applied to both coils C-C and A-A. This creates two

magnetic fields (only one is shown for simplicity), which add up to a vector sum which is mid-way between poles A-A and C-C. The vector sum runs from about the 11 o'clock position to about the 5 o'clock position. The rotor moves to align with this vector.

Thus, in full-stepping, the rotor aligns with the poles shown and can assume one of six positions. In half-stepping, the rotor can align with those same six positions, plus the six positions mid-way between those six positions, for a total of twelve positions.

Therefore, as so far described, the motor of Artus can be operated in full steps or half steps. In the latter case, the situation of Sketch 4, above, occurs, wherein the magnetic fields cancel, and Artus' tab 52, does not produce the added field needed to reduce cogging torque.

Further, Artus' motor can be operated in "micro-stepping," which is a variation of half-stepping. In micro-stepping, the field shown at the left side of Sketch 8, above, is generated. In addition, another field (not shown) is generated by coils A-A, running from the 12 o'clock position to the six o'clock position. These two fields add vectorially.

However, the two fields are modulated so that the vector sum gradually sweeps from that shown at the left side of Sketch 8, to a single field running from the 12 o'clock position to the six o'clock position. In this way, the rotor can be stepped to a theoretically infinite number of positions between the two poles in question (and between any two poles generally).

In micro-stepping, the situation of Sketch 4 above occurs, but full cancellation does not occur during the entire stepping sequence.

Other modes of operation exist in stepper motors.

Interim Conclusion 3

The PTO has not shown that Artus is operated in a manner wherein a net magnetic field is generated, which extends downward (toward the rotor) from tab 52 in his Figure 4. As just explained, certain modes of operation do not produce such a field.

Feature 6

At least one claim states that cogging is present after power is terminated. (This can occur in the permanent-magnet motor of Applicants' Figure 5.) As explained above, this is not present in Artus.

Feature 7

Artus states that some pole members are "winding pole members" (that is, have a coil wound around them). He states that other pole members are "non-winding pole members" (ie, have no coils). (Column 3, lines 20 - 24.)

Some of Applicants' claims state that every pole has a winding, contrary to Artus.

One Summary of Artus

Applicants respectfully submit that Artus does not face the problem of cogging torque. Thus, cogging torque cannot be reduced, as claimed. He states that he reduces, or eliminates, leakage flux, but leakage flux is necessary for the invention. Accordingly, Applicants respectfully submit that Artus is operated in a manner wherein a net magnetic field is present at tab 52 in Artus' Figure 4.

RESPONSE TO 35 USC § 102 - REJECTIONS BASED ON ARTUS

Claims 2 - 9 were rejected under section 102, based on Artus.

Claim 2

Claim 2 recites:

An electric motor, comprising:

a) a pair of stator teeth, having a stator slot therebetween, said stator slot having a slot opening which faces a rotor in the motor which rotor rotates about an axis; and

b) means for increasing magnetic flux passing through the slot opening, wherein the means

(1) comprises a body which is located radially outward of the slot opening and located farther from said axis than the slot opening, and

(2) reduces cogging torque.

As explained above, Artus does not face the problem of cogging torque, so that he does not reduce cogging torque as claimed.

Further, even if Artus does increase the "magnetic flux passing through the slot opening" in his Figure 4, as claimed, Applicants submit that this would not reduce cogging torque.

The primary reason is shown in Sketches 1 and 2 above. The added flux changes nothing because the amount of iron leaving a region below a tooth on the stator is equal to the amount of iron entering the region. A similar conclusion applies to Sketch 2. (This assumes operation outside saturation.)

Claims 3 - 9

The discussion of claim 2 applies to claims 3 - 9.

In addition, claim 9 states "wherein the body reduces cogging torque of the motor when no current is applied to the motor." As explained above, this does not occur in Artus.

Additional Point

For a reference to be anticipatory under section 102, the reference must teach of each element and be enabling. As explained above, Artus states that he eliminates (or reduces) leakage flux. If that is done, then no flux exists which can run from his tab 52 in his Figure 4 to the rotor.

Thus, it appears that Artus, as interpreted by the Examiner, actually teaches against enablement of Applicants' invention.

Conclusion

Therefore, Applicants submit that Artus does not show claims 2 - 9. Accordingly, Applicants respectfully submit that these claims should be allowed.

RESPONSE TO 35 USC § 102 - REJECTIONS BASED ON HSU

In Paragraph 3 of the Office Action, the Examiner rejected claims 11 - 17, 28, 29, and 35 - 37 under 35 USC 102(e) as being anticipated by Hsu.

Claim 11

Claim 11 states:

In an electric motor having a rotor, the improvement comprising:

a) stator coils, and

b) stator core means for decreasing mid-phase reluctance of the rotor, wherein the stator core means comprises a slot having a straight central axis, and said central axis is non-radial.

Point 1

Claim 11(b) states that the "central axis" is NON-RADIAL. The Office Action's mark-up on page 4 shows a RADIAL axis. That is OPPOSITE to the claim recitation.

Applicants request that the "straight" "non-radial" "central axis" be identified in Hsu.

Point 2

Applicants point out that claim 11(b) recites a "means." Regarding "means" usage, section 112 states:

An element in a claim for a combination may be expressed as a

means . . . for performing a specified function . . .

and

such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.

Thus, the "means" covers two things: (1) the "structure" etc. "described in the specification" and (2) "equivalents."

The PTO has not shown the "structure" "described in the specification" in Hsu. Nor has the PTO shown an "equivalent."

Applicants thus submit that claim 11 has not been shown in the Hsu reference.

Point 3

Claim 11(b) recites "stator core means for decreasing mid-phase reluctance of the rotor."

Applicants point out that the PTO's interpretation of Hsu is opposite to this recitation.

Regarding "reluctance," Applicants point out a simple mnemonic, which makes an analogy to resistance. Electrical "resistance" resists the flow of current. A large resistance allows a small current to flow, while a small resistance allows a large current to flow.

Magnetic "reluctance" is reluctant to allow a magnetic field to exist. A large reluctance allows a small magnetic field, while a small reluctance allows a large magnetic field.

Since a magnetic field "flows" easily in iron, compared to air, placing an iron body in the slot, as in Figures 13 et seq. of Applicants' Specification, will decrease the reluctance. The magnetic field will increase.

In returning to the rejection, Applicants point out that the Office Action, page 4, asserts that "the protrusion at the end of a stator tooth collects the flux leakage at the slot opening." If that be true, that is opposite to the claim language.

If the "flux leakage" is "collected," then the "flux" is no longer present at the "central axis" shown in the Office Action's mark-up on page 4. It is "collected" by the protrusion (that is, the "toe" of the "foot" shown in the PTO's mark-up.)

If the flux is no longer present (that is, reduced because collected), then the reluctance has effectively increased in the central region between the teeth. That is opposite to what is recited in claim 11.

Claim 12

The claimed "central axis" is not shown in Hsu. The claimed "central axis" cannot be the radial central axis shown on page 4 of the Office Action.

Claim 13

Claim 13 states that the "slot opening" is "non-radial." Applicants' Figure 13 provides an example.

The opening on page 4 of the Office Action is "radial," and the mark-up drawing in the Office Action indicates a radial line along which the slot lies. That slot is believed to be radial, which is opposite to the element in claim 13.

Claim 14

Claim 14 states:

> The improvement according to claim 13, wherein the non-radial slot opening decreases mid-phase reluctance of the rotor, compared with a radial slot opening.

The Office Action asserts that addition of the "toes" to the "ankle" in Hsu serves to reduce reluctance at the mid-point between the teeth. Applicants respectfully submit that this is not relevant, even if true.

It is not relevant because the claimed "non-radial" slot is not found in Hsu.

Claim 15

The discussion of claim 14 applies here. The "non-radial slot" is not found in Hsu.

Claim 16

The discussion of claim 12 applies here.

Claim 17

Claim 17 recites two "walls." The "walls" shown in the Office Action, page 4, define a radial slot. That is contrary to the claim. The claim recites a non-radial slot.

Claim 28

Point 1

The claim recites

-- two "regions of constant radius" and

-- two "circumferential boundary regions."

None of these four elements have been identified in Hsu. MPEP § 2131 states:

A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference. The claim further states that the "boundary regions" are not parallel to a "radial line." These elements are not shown in Hsu.

Point 2

The slot on page 4 of the Office Action has radial walls. That cannot correspond to the circumferential regions discussed in Point 1 above.

Claim 29

Claim 29 has not been shown in the reference.

Claim 35

Point 1

The elements of claim 35 have not been identified in Hsu. The Office Action merely sets forth the conclusory assertion that these elements are present in the reference. Applicants point out that a conclusory assertion is insufficient and respectfully request an identification of the elements in the reference.

Point 2

The claim states that the "section" of the "second stator tooth" is radially inward of the "second section." Hsu does not show that. The "toe" of the tooth, shown on page 7, is not "radially inward" of the "second section."

Claim 36

Claim 36 recites a "slot" having a "central axis" which is "non-radial." That is not found in Hsu.

RESPONSE TO 35 USC § 102 - REJECTIONS BASED ON MASLOV

In paragraph 4 of the Office Action, the Examiner rejected claim 27 under 35 USC 102(e) as being anticipated by Maslov et al.

Applicants assume that "Nutter" on page 8 of the Office Action refers to "Maslov."

Point 1

Applicants point out that the claim states that the teeth are surrounded by "coils." Maslov's Figure 1 shows coils 38. (Column 2, line 40). Thus, the teeth in question must be the elements 31 in his Figure 3.

Claim 27(c) recites “an elongated space separating the first and second stator teeth”, and that this "space" has "a central axis which is non-radial."

The "space" in question in Maslov must be that between elements 31 and any "central axis" of this "space" is NOT "non-radial," as claimed in claim 27.

Point 2

The diagram on page 9 of the Office Action has reversed "radially inner" and "radially outer." The element 36 is inside elements 21. (See Maslov's Figure 5.)

For all the foregoing reasons and in view of the amended claims as now presented, Applicants believe all claims as now pending are not anticipated by the references cited by the Examiner, and accordingly, they should be allowed.

The Commissioner is hereby authorized to charge any additional fees under 37 C.F.R. 1.16 and 1.17 which may be required by this paper, or to credit any overpayment, to Deposit Account No. 50-1287. Applicants hereby provide a general request for any extension of time which may be required at any time during the prosecution of the application. The Commissioner is also authorized to charge any fees which have not been previously paid for by check and which are required during the prosecution of this application to Deposit Account No. 50-1287. (Should Deposit Account No. 50-1287 be deficient, please charge any further deficiencies to Deposit Account No. 10-0220).

Applicants request an interview if no allowance is granted and invite the Examiner to contact the undersigned via telephone with any questions or comments regarding this case.

Reconsideration and favorable action are respectfully requested.

Respectfully submitted,

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